44TH TURBOMACHINERY & 31ST PUMP SYMPOSIA
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GEORGE R. BROWN CONVENTION CENTER

# CFD STUDY OF FAILURE IN AN OIL FLOODED SCREW COMPRESSOR JOURNAL BEARING


Diogo Yoshikazu Ujihara - PETROBRAS

Marcelo Accorsi Miranda - PETROBRAS

Mateus Louis Vieira - PETROBRAS

Lucilla Coelho de Almeida - ESSS

Rodrigo Peralta Muniz Moreira - ESSS


PETROBRAS

TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY

# THE AUTHORS

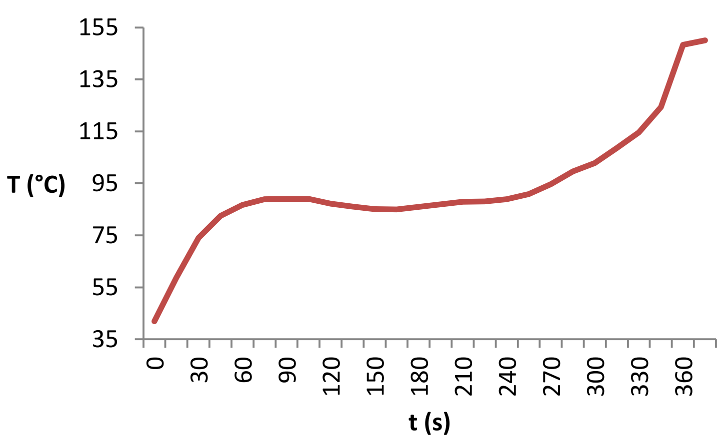

- **Diogo Yoshikazu Ujihara** (ujihara.hope@petrobras.com.br): MSc mechanical engineer; rotordynamics specialist; 4 yrs xp
- **Marcelo Accorsi Miranda** (maccorsi@petrobras.com.br): MSc mechanical engineer; senior turbomachinery advisor; 35 yrs xp
- **Mateus Louis Vieira** (mateuslvieira@petrobras.com.br): mechanical engineer; turbomachinery specialist; 3 yrs xp
- **Lucilla Coelho de Almeida** (lucilla.almeida@esss.com.br): MSc chemical engineer; CAE applications specialist; 6 yrs xp
- **Rodrigo Peralta Muniz Moreira** (peralta@esss.com.br): chemical engineer; CAE applications specialist; 6 yrs xp

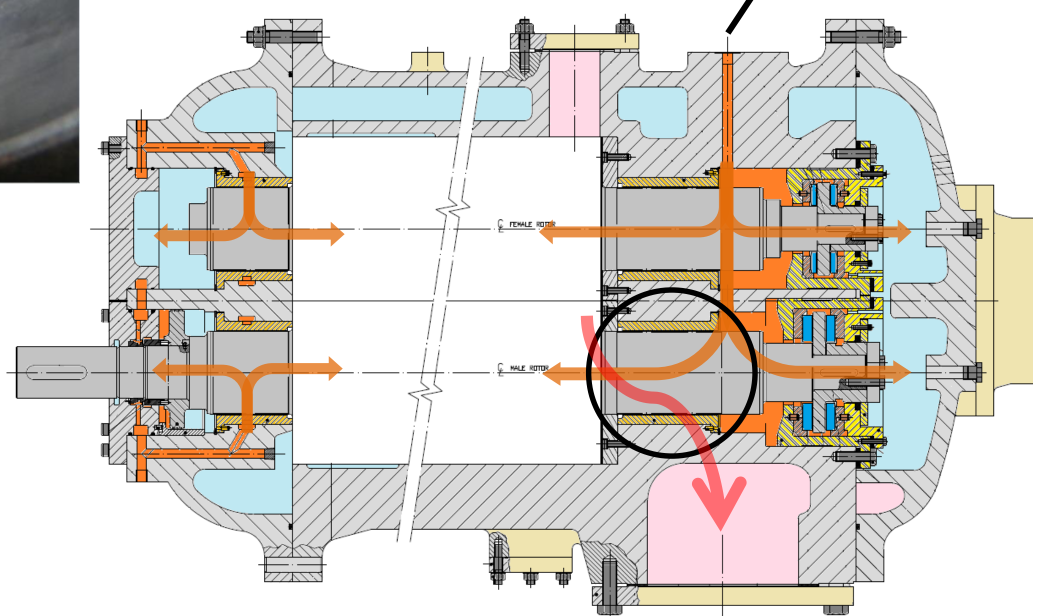
# THE PROBLEM

- Journal bearing failures (white metal melting) during commissioning of an new oil flooded screw compressor for vapor recovery service
- Only one bearing damaged (male NDE), but all journal bearings with high temperature
- Bearing without direct oil injection; located near the discharge; different from other bearings
- Trend analysis of available data was performed and some possible causes were identified

# THE MACHINE

Oil flow
(orange path)



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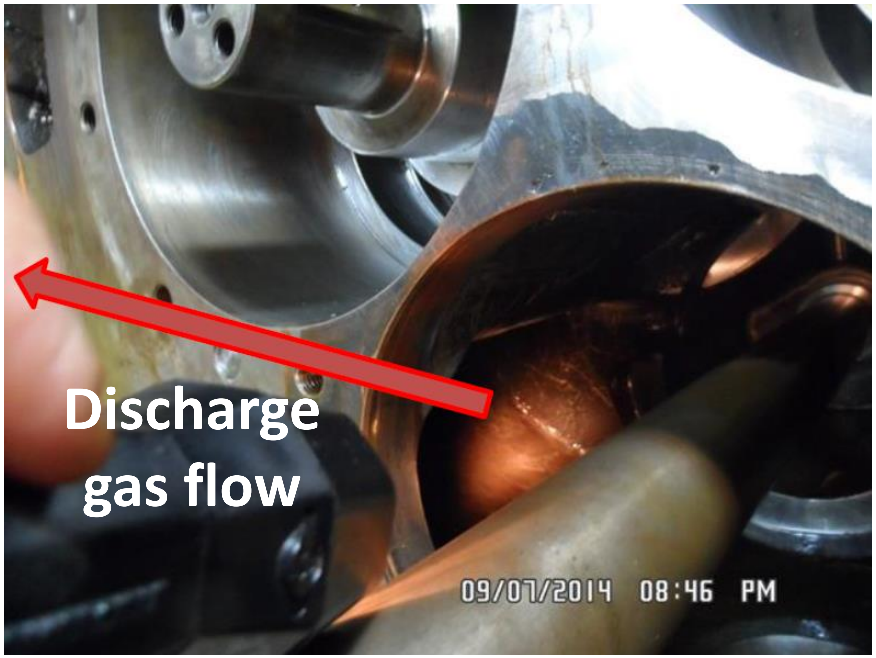
Discharge
gas flow
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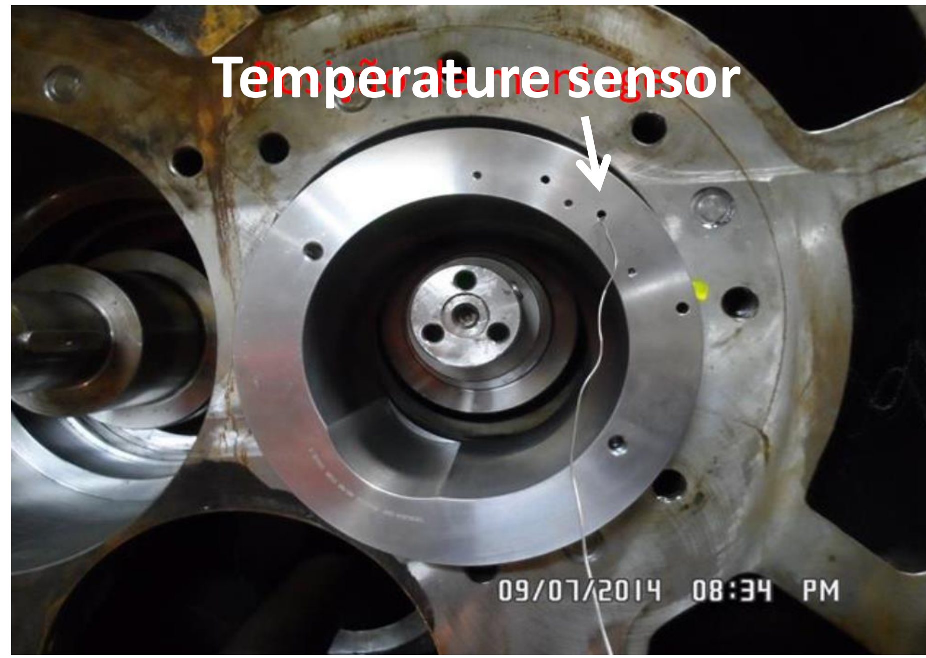
Temperature sensor
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# POSSIBLE CAUSES

- **Low oil flow** due to bearing design and lubricating system adjustment
- **Wrong oil specification:** much lower than expected gas dilution due to high viscosity oil
- **Heat transfer from discharged gas to bearings:** high proximity between both; absent in past designs
- **Low gas flow** leading to low heat dissipation
- ***Overcompression* phenomenon:** discharge gas pressure higher than oil pressure

# DISCUSSIONS

- A spare compressor test at OEM was anticipated and after discussions, some modifications were tested to improve oil flow and then used at field
- Heat transfer and low gas flow were considered as low impact causes (discharge gas temperature nearly constant in all cases)
- Overcompression was not considered as a possible cause at this time

# CFD STUDY

- Modifications were adopted at field before the study conclusion
- The CFD study was conducted to reproduce flow and temperature profiles of the damaged bearing and estimate the effectiveness of modifications
- Only cases related to lubrication problems were simulated (low oil flow and wrong oil specification)
- Load and load directions were informed by OEM (input to CFD model)
- Eccentricity was estimated with “adapted” classic bearing theory (input to CFD model)

# CFD STUDY

- Essentially centered, zero orbit (non deformable mesh), steady state, no gas dilution (single phase)
- Oil exit specified as opening type, allowing oil to return
- Specified average oil pressure at bearing exit instead of circumferentially variable (model simplification)
- Solid domains included, allowing heat transfer between oil and bearing surface
- Viscous dissipation term included (= heat generation)
- SST model for fluid turbulence

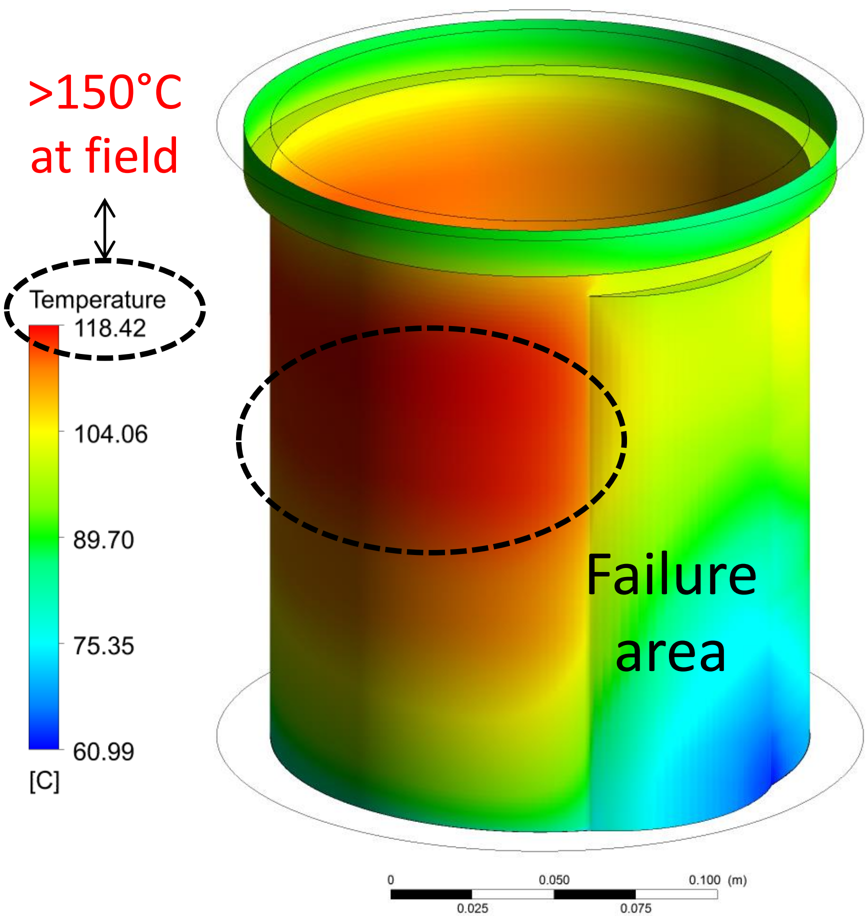
# ADOPTED MODIFICATIONS

- **Male NDE** clearance increase (0,19 to 0,24mm)
- Oil change (Kluber PGS 150 to PGS 100)
- Oil pressure increase (+2,5bar)
- Oil supply temperature reduction (50°C to 45°C)
- Individual oil injection to male NDE bearing
- Oil injection's logic modification to prevent an eventual oil pressure drop in the oil header
- Suction pressure reduction (1,80 to 1,35bara as designed)

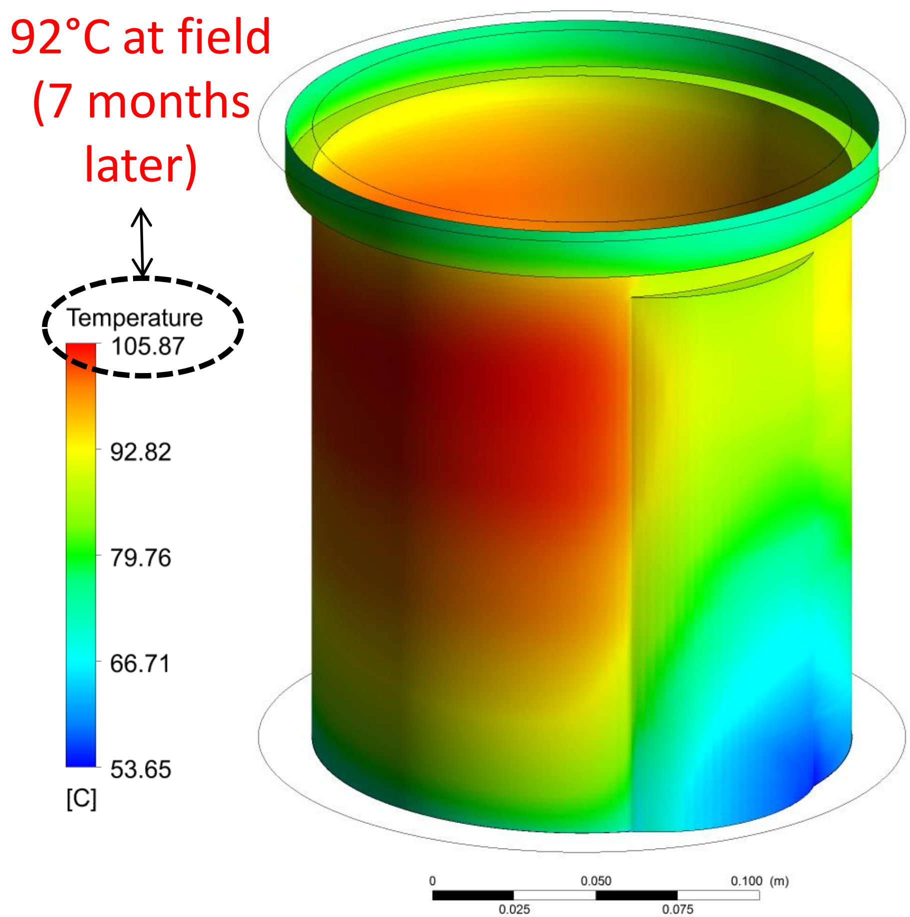
# CFD RESULTS

- Temperature profile at **oil-bearing interface:**

Before modifications



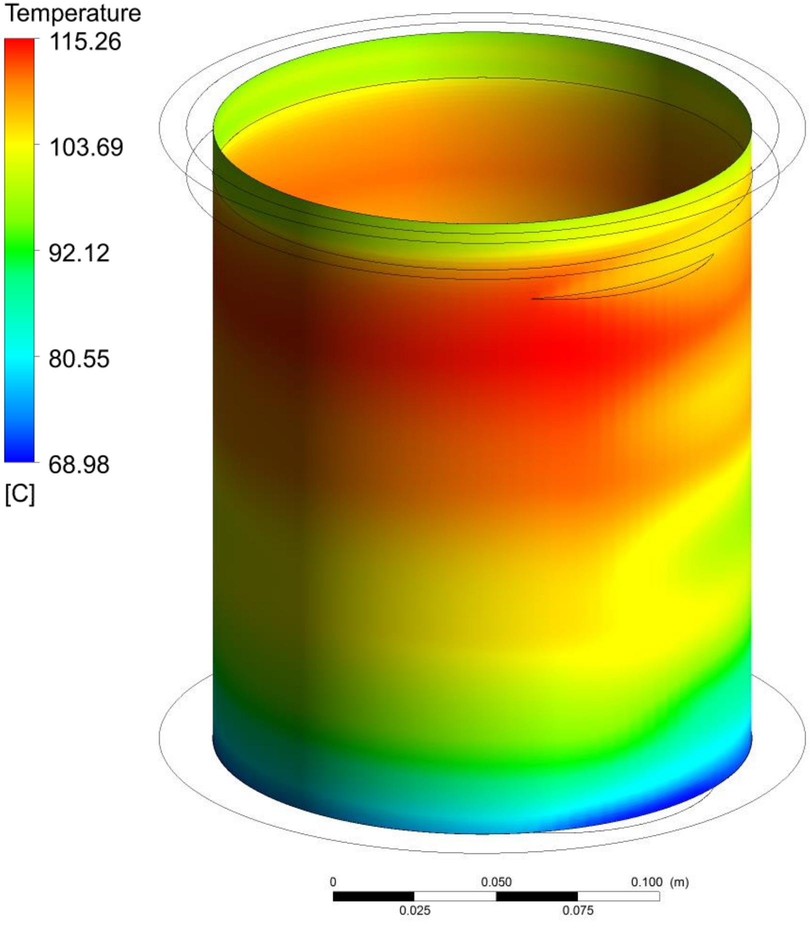

After modifications



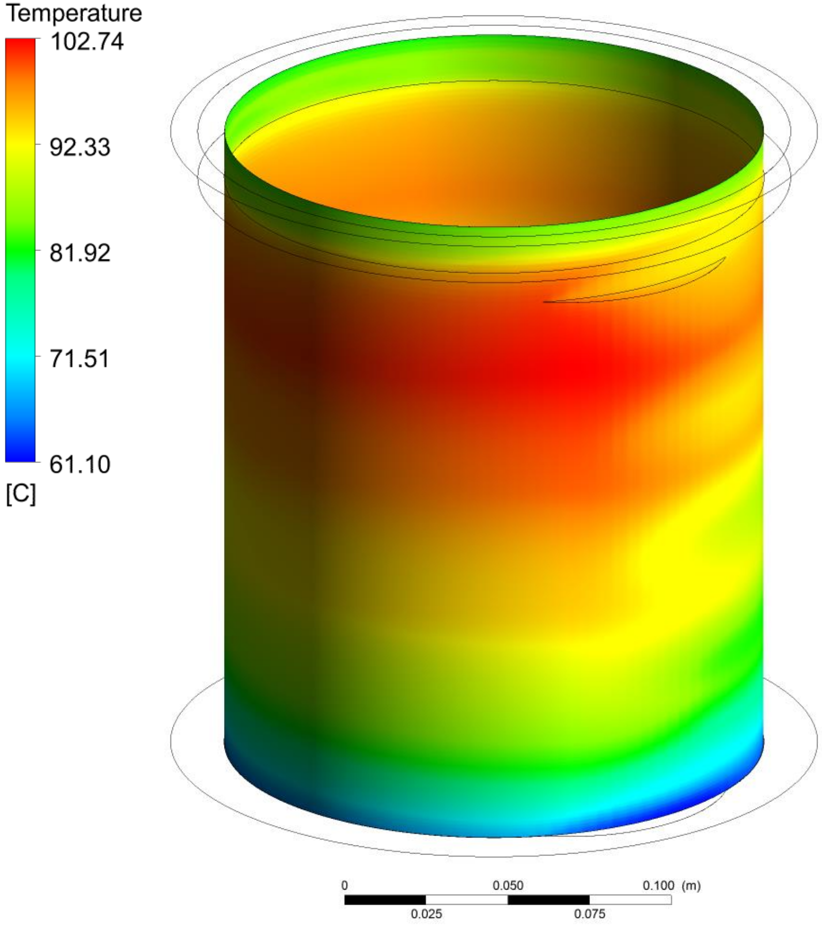
# CFD RESULTS

- Temperature profile at **oil-shaft interface:**

Before modifications

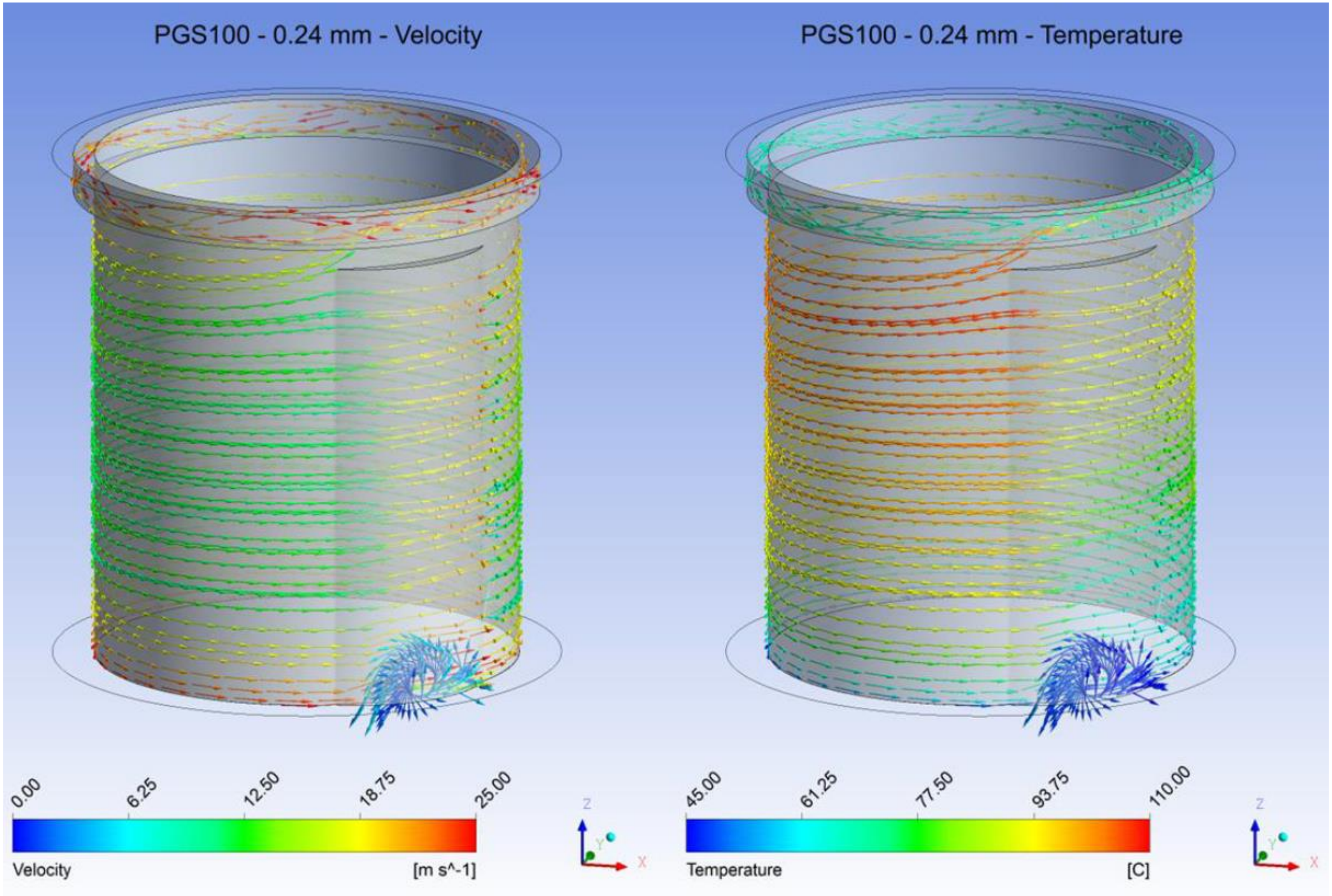



After modifications



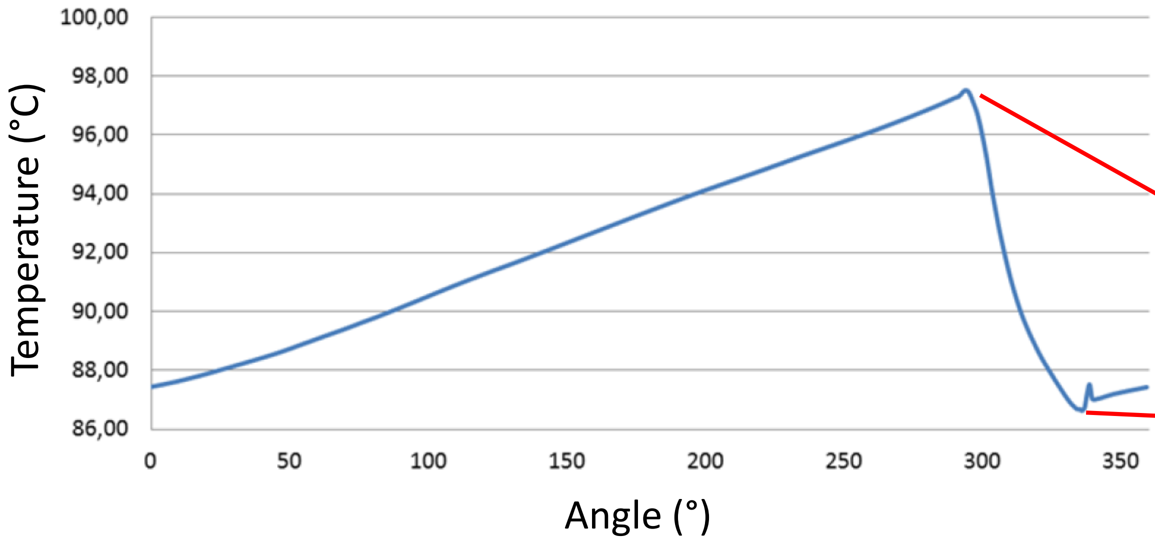
# CFD RESULTS

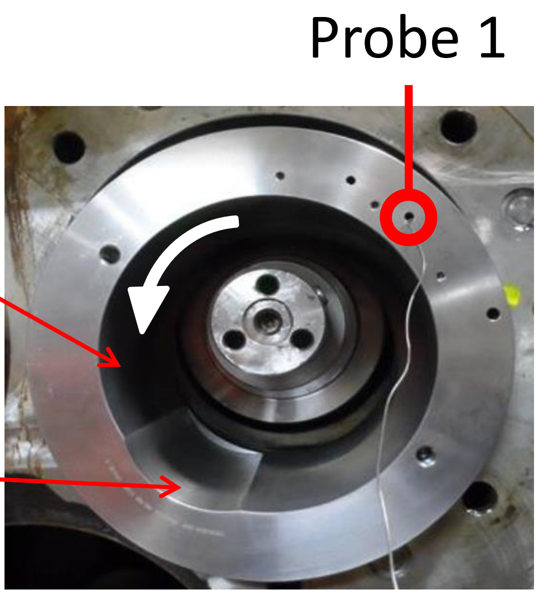
- Profiles after modifications:



# CFD RESULTS

**Temperature at probe 1 cross section after modifications**



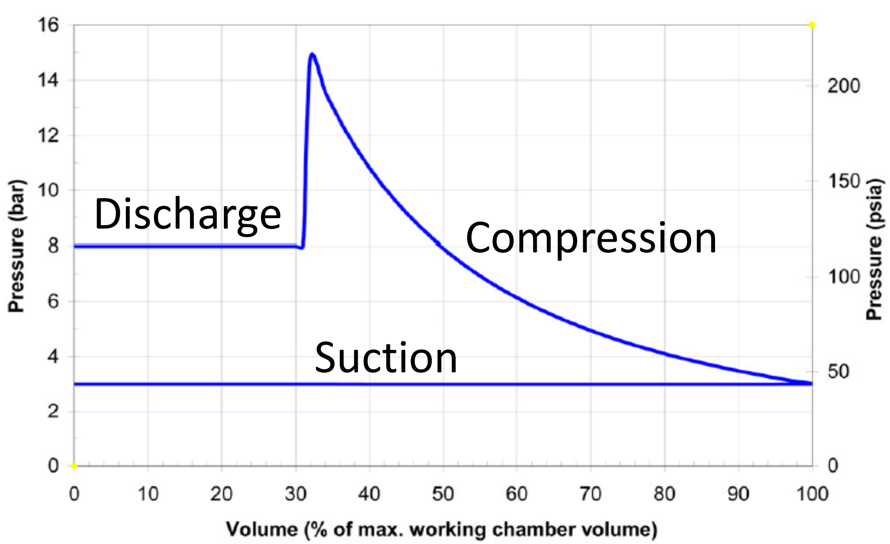

- Stabilized around 92°C after 7 months

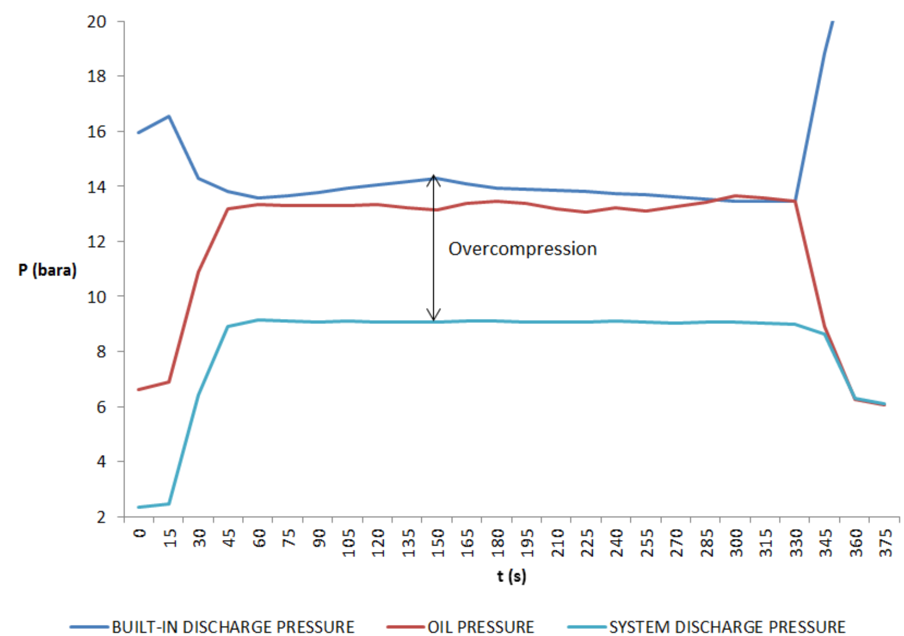
# FIELD RESULTS

- All bearing temperatures were reduced and stabilized:
  - **Male NDE:** >150°C to 92°C (7 months later)
  - **Male DE:** 111°C to 79°C
  - **Female NDE:** 111°C to 85°C
  - **Female DE:** 101°C to 75°C
- No visible impact on vibration (machine monitored only by two frame accelerometers)

# OVERCOMPRESSION

- High suction pressure, leading to an increase of built-in discharge pressure
- Oil pressure could be lower than the built-in discharge pressure, allowing gas into the bearing



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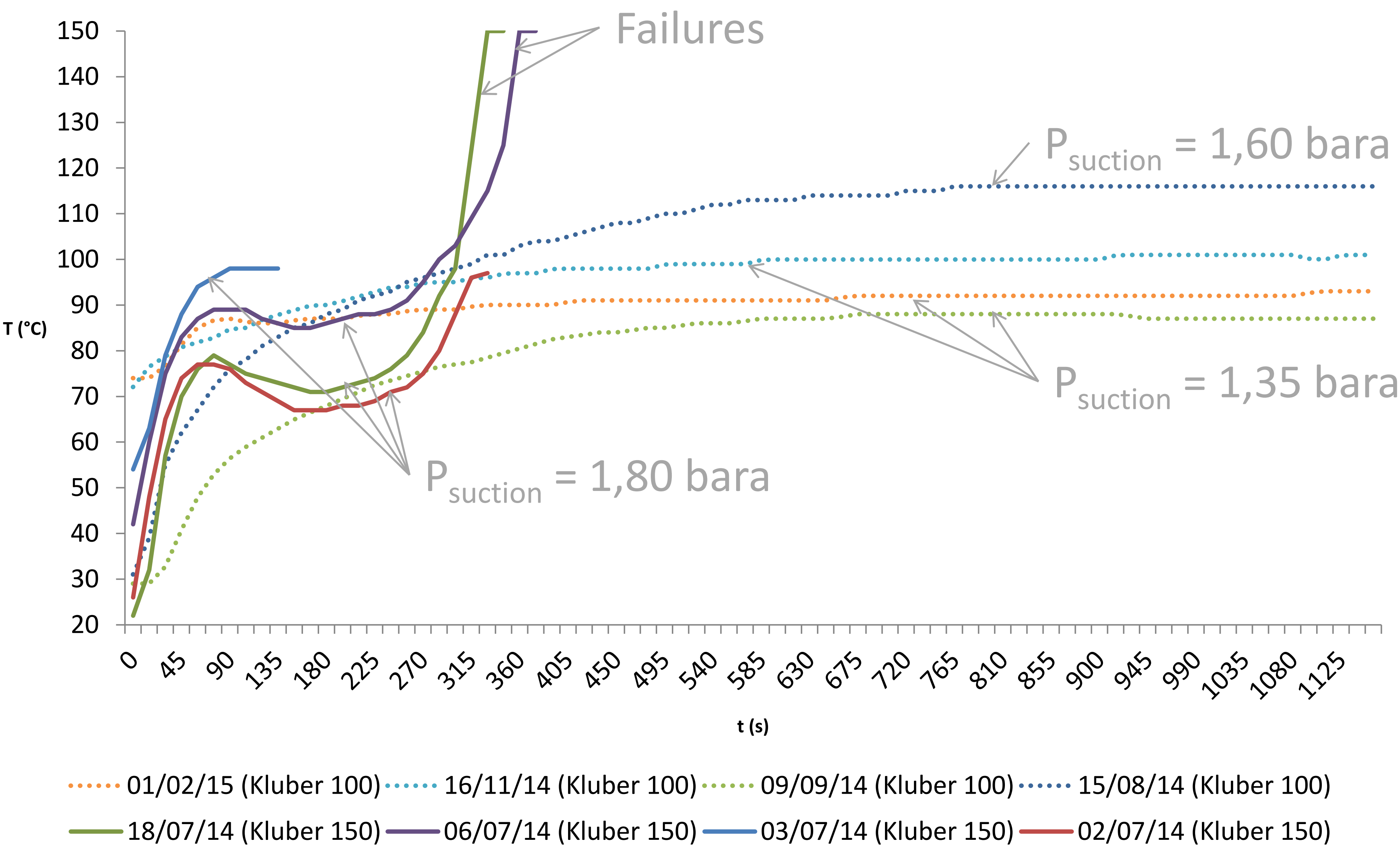

# CONCLUSIONS

- The proposed modifications were satisfactory, indicating that the main causes of bearing failures probably were "**low oil flow**" and "**wrong oil specification**"
- Test conditions for both installed and spare compressors were different from operational conditions (ISO VG68 oil and air running instead of Kluber PGS150 and process gas)
- Overcompression could have contributed to failures, but it was not confirmed
- Good agreement between field data and numerical results, indicating good boundary assumptions and suitable simplifications

# LESSONS LEARNED

- Difficulty to model real conditions (transient start up, variable pressures, heat transfer from discharge)
- Sensitivity to viscosity and bearing clearances
- It is important to work within the designed pressure limits in order to avoid undesirable phenomena like overcompression